

Evaluation of Effect of LCS (Lane Control System) on Expressway

Lee, Seungjun^{*}, Choi, Yoonhyuk^{}, Kim, Taeyoung^{***}**

Transportation Research Division

Expressway & Transportation Research Institute

I . INTRODUCTION

The bus lane in the section from Osan to Hannam on Kyungbu Expressway was implemented in July 1st, 2008 and enforcement to violated vehicles was begun on October. Due to this policy implementation, the number of lane for passenger cars on Kyungbu Expressway was decreased from four to three. On the other hand, total traffic demand was decreased just a little so that lots of congested sections were occurred in the section where bus lane was implemented. In special, in south bound on Kyungbu Expressway, the congestion occurred from Suwon IC reaches to Seoul Toll-gate and the range of congested section is about 12km. To solve this problem, Korea Expressway Corporation performed the study to analyze the cause of congestion and evaluate the effect of improvement alternatives. At the same time, estimation for traffic operating condition after enforcement was performed.

II . Outline of Bus Lane Policy on Kyungbu Expressway

Kyungbu Expressway is symbolic road which has led the economic growth of South Korea.

The Bus Lane policy on Kyungbu Expressway has two aims. One is to decrease severe traffic congestion and the other is to encourage public transportation.

<Figure 1> Location of Kyungbu Expressway in Korea



With those aims, Bus Lane policy was implemented. The process of Bus Lane policy on Kyungbu Expressway is as follows;

- To make a plan for the Bus Lane policy on Kyungbu Expressway (2008. 2)
- To examine the feasibility of Bus Lane policy (2008. 3-6)
- To start Bus Lane policy without enforcement (2008. 7-9)
- To operate Bus Lane policy with enforcement (2008. 10)

1. Comparison of travel demand between before and after Bus Lane policy implementation

Travel demand between before and after Bus Lane policy implementation was compared to know the change of traffic conditions. In the analysis, the used data for before Bus Lane policy implementation was those of early six months and the used data for after Bus Lane policy implementation was those of later six months, because Bus Lane policy was begun in July 2008.

Table 1 shows passenger car and total travel demand on Kyungbu Expressway from January to Jun in 2007 and 2008 each. As shown Table 1, the travel demand variation between 2007 and 2008 is not large. On the other hand, Table 2 shows a large amount of travel demand decrease after Bus Lane policy implementation in 2008, compared with travel demand in 2007.

Particularly, as shown in Table 2, passenger car travel demand was decreased very largely. In addition, during the period from September to December, when enforcement was started, travel demand was decrease more than 10% compared with that of previous year.

<Table 1> Variation of travel demand before Bus Lane policy implementation

(Unit: vehicle/day, %)

		January	February	March	April	May	Jun
Passenger Car	2007	173,192	178,668	181,124	186,718	187,530	184,737
	2008	171,789	179,865	184,391	186,439	187,425	181,037
	Rate	-0.81	0.67	1.80	-0.15	-0.06	-2.00
Total	2007	200,465	205,856	210,593	217,976	218,089	214,295
	2008	200,310	208,281	214,688	217,434	218,432	210,608
	Rate	-0.08	1.18	1.94	-0.25	0.16	-1.72

<Table 2> Variation of travel demand after Bus Lane policy implementation

(Unit: vehicle/day, %)

		July	August	September	October	November	December
Passenger Car	2007	184,923	188,544	188,318	189,976	188,239	179,654
	2008	168,418	175,015	173,396	164,221	161,902	155,229
	Rate	-8.93	-7.18	-7.92	-13.56	-13.99	-13.60
Total	2007	212,699	215,738	218,058	221,016	218,907	208,615
	2008	196,517	203,169	203,131	194,810	191,633	183,674
	Rate	-7.61	-5.83	-6.85	-11.86	-12.46	-11.96

2. Comparison of Traffic Condition

1) Average travel speed

Southbound average travel speeds of before and after Bus Lane policy implementation are shown in Table 3. In Table 3, average travel speeds in each section before Bus Lane policy implementation are 94km/h in the section from Seoul Toll to Suwon IC and 84km/h in the section from Suwon IC to Giheung IC. In the period without enforcement, from July to September in 2008, average travel speeds on a Bus Lane in each section are 98km/h and 95km/h. And average travel speeds on General Lanes in each section are 80km/h and 68km/h.

Whereas, In the period with enforcement, from October to December in 2008, average travel speeds on a Bus Lane in each section are 105km/h and 96km/h. And average travel speeds on General Lanes in each section are 71km/h and 63km/h. With these results, it was found that average travel speed on a Bus Lane was increased, but average travel speed on General Lanes was decreased because of Bus Lane policy implementation. Furthermore, through the effect of enforcement, average travel speed on a Bus Lane was much more increased, but average travel speed on General Lanes was much more decreased.

<Table 3> Comparison of travel speed between before and after Bus Lane policy

implementation

(Unit: km/h)

			Seoul Toll ~ Suwon IC		Suwon IC ~ Giheung IC	
			Bus Lane	General Lane	Bus Lane	General Lane
Before		January ~ Jun	94		84	
After	No enforcement	July ~ September	98	80	95	68
	Enforcement	October ~ December	105	71	96	63

2) Traffic congestion

As shown in Table 4, the range of average congestion section on Kyungbu Expressway (southbound) before Bus Lane policy implementation was 2.7km, from Singal JC to Suwon IC.

On the other hand, the range of average congestion section in the period without enforcement after Bus Lane policy implementation was 7.5km, from Jukjeon to Suwon IC. And also, the range of average congestion section in the period with enforcement after Bus Lane policy implementation was 12km, from Seoul Toll to Suwon IC.

From these results, it was known that the range of average congestion section after Bus Lane policy implementation was increase rapidly compared with that of before Bus Lane policy implementation. Moreover, it is also known that the range of average congestion section in the period with enforcement was more increased than that of in the period without enforcement.

<Table 4> Comparison of traffic congestion section between before and after Bus Lane policy implementation

		Congestion section	Maximum congestion
Before	January ~ Jun	Singal JC ~ Suwon IC	2.7km
After	July ~ September (No enforcement)	Jukjeon ~ Suwon IC	7.5km
	October ~ December (Enforcement)	Seoul Toll ~ Suwon IC	12km

3. Analysis of traffic congestion problem

Traffic congestion on Kyungbu Expressway (southbound) was caused due to merging flow on Suwon IC, so it could be said that Suwon IC merging section was operated as a bottle-neck

section on Kyungbu Expressway (southbound). From the Bus Lane policy implementation, the effect of traffic congestion occurred from Suwon IC was up to Seoul Toll.

It can be said that the level of traffic congestion at present like this is the level of equilibrium condition. That is, through the Bus Lane policy implementation, much more severe traffic congestion was occurred than before and thereafter considerable traffic demand was decreased and present traffic equilibrium condition was reached.

III. Analysis of Effect of LCS (Lane Control System)

After Bus Lane policy implementation without enforcement, there was slightly severe traffic congestion and it was expected that much more severe traffic congestion would occur in the period with enforcement. So, the exertion to find out the cause of traffic problem was done by the field survey and traffic data collection and analysis. After this, another exertion to search for alternatives for improvement was followed.

As a result, it was found that the merging area of Suwon IC caused the congestion because a lot of vehicles entered into main line from on-ramp of Suwon IC. And also, it was found that enlargement of main line section from Suwon IC merging area to Giheung IC diverging area because a lot of vehicles exited into off-ramp of Giheung IC from main line could be effective to reduce the traffic congestion and robust improvement alternative. Finally, after examinations

for various alternatives, it was concluded that enlargement of main line section from on-ramp of Suwon IC to off-ramp of Giheung IC was robust alternative.

Traffic analysis program used for the research was ExTrAM (Expressway Traffic Analysis Model) which was developed by the researchers of KEC (Korea Expressway Corporation).

1. Assumption and Precondition

☐ Alternative

- Operation of LCS through enlargement of main line from on-ramp of Suwon IC to off-ramp of Giheung IC

☐ Violation rate of other vehicles on Bus Lane

- 20% of Bus Lane volume

☐ Classification of analysis cases

- Case 1: Bus Lane policy implementation without enforcement
- Case 2: Bus Lane policy implementation with enforcement - in this case, violation traffic, 20% of Bus Lane volume moves to General Lane from Bus Lane

2. Analysis Results

☐ **Present traffic condition**

Figure 2 shows travel speed in each time period on Kyungbu Expressway (southbound) from Seoul Toll to Giheung IC for weekdays during the period of Bus Lane policy implementation without enforcement. As shown in Figure 2, traffic congestion was occurred from Suwon IC and reached to Jukjeon. Maximum average traffic congestion is about 7.5km.

□ **Analysis: Case 1**

As shown in Table 5 and Figure 3, the analysis results of case 1 is as follows;

○ Do Nothing

- Maximum range of traffic congestion: 8.5km
- Total delay cost: 179 million Won/Day (45,014 million Won/Year)

○ Do Alternative

- No traffic congestion

□ **Analysis: Case 2**

As shown in Table 5 and Figure 4, the analysis results of case 2 is as follows;

○ Do Nothing

- Maximum range of traffic congestion: 11.8km
- Total delay cost: 305 million Won/Day (76,763 million Won/Year)

○ Do Alternative

- No traffic congestion

<Figure 2> Present Traffic Condition (Seoul Toll → Giheung IC)

구간별 지체세도(2008. 9. 1(월))-속도																				
구간	이정(km)	06:00	07:00	08:00	09:00	10:00	11:00	12:00	13:00	14:00	15:00	16:00	17:00	18:00	19:00	20:00	21:00	22:00		
수원IC→기흥IC	390.75	95	84	-999	96	-999	-999	42	90	94	104	104	110	107	93	77	80	77		
	391.84	92	69	-999	73	-999	-999	73	76	74	72	78	82	83	79	79	81	82		
	393.31	30	64	-999	-999	-999	-999	57	56	62	62	66	81	85	79	77	73	78		
	394.46	95	46	-999	30	-999	-999	39	40	39	39	63	66	66	83	64	87	66		
신갈IC→수원IC	395.85	103	51	-999	20	-999	-999	-999	26	32	31	83	92	93	82	79	86	88		
	396.70	89	64	-999	25	-999	-999	25	23	27	59	75	81	78	70	70	75	75		
	397.79	103	87	-999	23	-999	-999	22	23	30	90	94	96	94	82	82	87	88		
	401.43	73	74	-999	26	-999	-999	60	63	89	87	89	79	100	72	81	82	91		
서플TG→신갈IC	402.52	-999	98	-999	-999	-999	-999	36	-999	87	83	97	-999	-999	-999	99	27	98		
	403.79	100	73	-999	51	-999	-999	40	90	87	12	80	82	82	74	77	81	82		
	405.13	-999	74	-999	62	-999	-999	78	-999	-999	-999	-999	84	83	-999	-999	-999	79		

구간별 지체세도(2008. 9. 2(화))-속도																				
구간	이정(km)	06:00	07:00	08:00	09:00	10:00	11:00	12:00	13:00	14:00	15:00	16:00	17:00	18:00	19:00	20:00	21:00	22:00		
수원IC→기흥IC	390.75	90	110	111	107	108	-999	109	113	109	111	99	111	120	134	99	91	90		
	391.84	95	85	77	81	80	81	80	82	77	79	70	85	84	90	89	89	88		
	393.31	36	83	68	64	66	65	64	66	65	63	69	84	87	81	88	88	88		
	394.46	99	86	59	45	41	35	37	39	41	40	72	87	89	93	92	93	91		
신갈IC→수원IC	395.85	107	94	67	41	39	24	26	33	40	39	83	96	101	96	92	97	97		
	396.70	92	82	80	44	32	26	29	28	27	29	69	82	82	82	81	83	84		
	397.79	106	99	94	90	79	20	34	31	30	42	80	106	104	98	103	100	100		
	401.43	62	76	72	78	76	69	26	27	57	93	70	83	83	83	76	81	83		
서플TG→신갈IC	402.52	-999	-999	92	-999	100	-999	38	37	61	98	78	93	99	94	91	95	95		
	403.79	104	80	77	83	79	84	36	39	74	94	75	90	93	89	88	92	93		
	405.13	92	-999	-999	-999	-999	78	-999	49	89	90	73	87	91	89	86	88	88		

구간별 지체세도(2008. 9. 3(수))-속도																				
구간	이정(km)	06:00	07:00	08:00	09:00	10:00	11:00	12:00	13:00	14:00	15:00	16:00	17:00	18:00	19:00	20:00	21:00	22:00		
수원IC→기흥IC	390.75	104	120	98	92	98	109	115	117	110	112	115	124	129	132	95	88	88		
	391.84	97	87	80	80	70	77	76	78	77	77	80	85	88	90	89	88	88		
	393.31	96	87	70	68	61	61	61	64	60	58	77	86	89	91	89	88	88		
	394.46	100	30	67	57	41	39	39	38	42	49	70	85	92	93	92	91	91		
신갈IC→수원IC	395.85	109	100	69	72	38	33	29	32	41	54	87	100	102	98	93	93	96		
	396.70	98	85	67	32	30	29	25	27	37	29	75	83	85	83	81	82	84		
	397.79	114	107	99	69	72	37	27	31	76	63	104	105	107	105	100	101	101		
	401.43	80	93	80	85	79	68	37	50	93	87	85	82	87	82	76	76	80		
서플TG→신갈IC	402.52	108	97	90	79	81	78	99	76	63	-999	95	95	-999	93	-999	90	92		
	403.79	106	81	88	28	65	68	96	86	92	92	92	91	92	90	91	93	93		
	405.13	97	88	80	84	71	52	63	87	74	87	90	91	91	90	89	89	89		

구간별 지체세도(2008. 9. 4(목))-속도																				
구간	이정(km)	06:00	07:00	08:00	09:00	10:00	11:00	12:00	13:00	14:00	15:00	16:00	17:00	18:00	19:00	20:00	21:00	22:00		
수원IC→기흥IC	390.75	102	121	107	105	99	107	113	119	110	119	-999	117	124	129	92	89	89		
	391.84	97	88	78	80	27	75	76	77	76	81	-999	84	87	87	87	89	88		
	393.31	97	87	63	65	63	62	62	63	62	75	-999	87	89	88	87	88	88		
	394.46	99	89	54	43	15	38	36	36	39	73	-999	88	89	91	91	91	91		
신갈IC→수원IC	395.85	81	95	63	37	13	31	37	30	41	88	-999	97	98	97	87	87	95		
	396.70	94	85	52	39	10	29	27	27	29	76	-999	79	82	81	78	82	84		
	397.79	116	109	100	82	14	30	29	29	46	103	-999	101	104	103	97	102	100		
	401.43	70	28	45	76	23	71	94	68	84	81	-999	79	83	83	76	85	82		
서플TG→신갈IC	402.52	105	100	96	97	-999	78	77	90	-999	-999	-999	98	94	94	89	97	-999		
	403.79	107	94	91	92	29	72	75	89	91	92	-999	88	90	88	87	96	93		
	405.13	98	91	86	88	31	62	82	86	88	90	-999	89	89	89	89	89	89		

구간별 지체세도(2008. 9. 5(금))-속도																				
구간	이정(km)	06:00	07:00	08:00	09:00	10:00	11:00	12:00	13:00	14:00	15:00	16:00	17:00	18:00	19:00	20:00	21:00	22:00		
수원IC→기흥IC	390.75	99	124	109	115	112	110	109	110	109	111	114	115	117	117	86	86	91		
	391.84	97	87	79	80	80	74	76	74	77	76	79	83	84	85	83	85	90		
	393.31	97	88	72	72	74	63	64	63	64	60	70	81	83	84	81	84	84		
	394.46	100	90	60	63	58	40	30	37	30	39	61	82	85	87	87	87	84		
신갈IC→수원IC	395.85	107	98	76	78	91	42	32	29	32	48	77	97	97	93	83	88	61		
	396.70	95	84	75	78	76	42	28	28	27	39	76	83	83	80	75	79	75		
	397.79	113	107	98	100	99	75	37	39	46	94	101	105	104	102	95	96	96		
	401.43	68	82	80	84	83	76	69	68	74	78	89	89	91	91	89	82	76		
서플TG→신갈IC	402.52	106	97	94	89	96	79	75	72	82	87	98	98	99	96	90	92	93		
	403.79	108	93	88	94	77	85	96	81	77	94	94	94	94	94	89	96	91		
	405.13	98	90	83	87	84	62	42	63	85	86	89	90	90	89	87	84	84		

<Table 5> Analysis Results of LCS Effect

Classification	MOE	Alternative		Effects
		Do Nothing	Do Alternative	
Case 1	Maximum Traffic Congestion (km)	8.5	-	8.5
	Total Delay Time (hour)	12,481	-	12,481
	Total Delay Cost (million ₩)	179 (Day) 45,014 (Year)	- -	179 (Day) 45,014 (Year)
Case 2	Maximum Traffic Congestion (km)	11.8	-	11.8
	Total Delay Time (hour)	21,284	-	21,284
	Total Delay Cost (million ₩)	305 (Day) 76,763 (Year)	- -	305 (Day) 76,763 (Year)

<Figure 3> Congestion Analysis Result in a Time-Space Diagram : Case 1

Interchange	Distance (km)	Do Nothing																						Do Alternative																					
		6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22										
Giheung IC	389.5																																												
	390.0																																												
(off-ramp)	390.5																																												
	391.0																																												
	391.5																																												
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	393.0																																												
(on-ramp)	393.5																																												
	394.0																																												
Suwon IC	394.5																																												
	395.0																																												
	395.5																																												
	396.0																																												
	396.5																																												
	397.0																																												
Singal JC	397.5																																												
	398.0																																												
	398.5																																												
	399.0																																												
	399.5																																												
Jukjeon	400.0																																												
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Seoul Toll	405.5																																												
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	407.5																																												
	408.0																																												
	408.5																																												
	409.0																																												

<Figure 4> Congestion Analysis Result in a Time-Space Diagram: Case 2

<Figure 4> Congestion Analysis Result in a Time-Space Diagram : Case 2

Interchange	Distance (km)	Do Nothing																						Do Alternative																					
		6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22										
Giheung IC	389.5																																												
	390.0																																												
(off-ramp)	390.5																																												
	391.0																																												
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	392.5																																												
	393.0																																												
(on-ramp)	393.5																																												
	394.0																																												
Suwon IC	394.5																																												
	395.0																																												
	395.5																																												
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	396.5																																												
	397.0																																												
Singal JC	397.5																																												
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	399.5																																												
Jukjeon	400.0																																												
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	408.0																																												
	408.5																																												
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IV. The Effect of LCS Implementation

KEC (Korea Expressway Corporation) implemented LCS on Kyungbu Expressway (southbound) from on-ramp of Suwon IC to off-ramp of Giheung IC in December 2008 based on the previous analysis results. As a result, the congestion between Suwon IC and Seoul Toll-gate was disappeared completely. After this, KEC are preparing another LCS implementation for other congestion sections on Kyungbu Expressway (northbound). Other congestion sections being prepared LCS implementation are as follows; from Giheung IC to Suwon IC, from Singal JC to Seoul Toll, from Seoul Toll to Pangyo IC.

V. Conclusion

Bus Lane policy was implemented for traffic congestion reduction and public transportation, but there were some problems because it was implemented without pre-examination on traffic condition. So, after Bus Lane policy implementation, the exertions to find out the cause of congestion problem and the effective alternative were performed. Fortunately, implementation of LCS on congested section had a great effect to reduce traffic congestion. However, a lot of money had to be paid for it. Therefore, it is needed to note that examination on any transportation policy before implementation has to be performed always.

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